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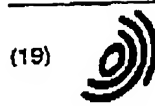
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(19)

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(11)

EP 0 720 322 A2

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:  
03.07.1996 Bulletin 1996/27

(51) Int. Cl.<sup>6</sup>: H04J 14/02, H04N 7/22

(21) Application number: 95120271.2

(22) Date of filing: 21.12.1995

(84) Designated Contracting States:  
AT BE CH DE FR GB IT LI NL SE

(30) Priority: 30.12.1994 ES 9402696

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## (54) Optical access communications network

(57) For subscriber access, via optical fibre, to communications networks that offer various types of service by means of an optical access node (AN). The connections between the optical network terminating equipments (ONT), to which the subscribers are connected, and the access node (AN) can be made with point-to-point or point-to-multipoint fibre optic links.

The links between the access node (AN) and the switching centre (CE) are made via optical fibres through which pass the lightwave signals corresponding to a

number of subscribers, multiplexed together by means of wavelength division multiplexing.

This network permits access to all types of communications services in which each type of service employs a reserved wavelength for its connection between the access node (AN) and the optical network terminating equipment (ONT). This reserved wavelength is fixed and depends only on the type of service.

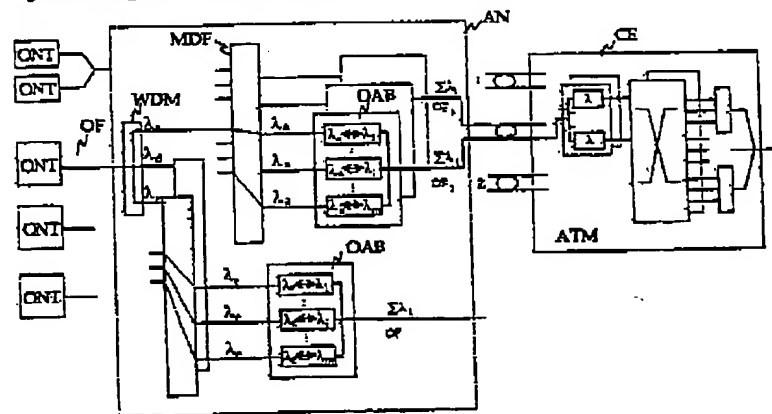


FIG. 2

## Description

OBJECT OF THE INVENTION

This invention concerns an access communications network, based on optical technology, located between network terminating equipments, on the subscriber side, and switching nodes which in general are service nodes (different types of centre, transparent routing nodes, etc.), for the provision of all types of user required services: narrow and/or broad band services, distribution services (radio and TV), video on demand (VOD), etc., and even semipermanent transparent optical channels.

The connection of the network terminating equipments to their respective service nodes is made through an optical type access network, which provides the links with the appropriate interfaces for these networks. This gives rise to an access network infrastructure that meets the Open Network Provision requirements, that is, it provides access for the subscribers to the services offered by a multi-service and multi-operator network in which one or more types of service can be provided by one or more operators. In this last case, a subscriber may select one from a number of networks to provide him with the service required.

BACKGROUND OF THE INVENTION

As a result of the vast amount of information expected to be transmitted over future communications networks through the setting up of new user services and the advantages that optical technology offers (broad bandwidth, reliability, security, etc.), consideration is being given to the need for using completely optical networks in which both transmission and switching take place in the optical domain, thereby avoiding the successive opto-electrical conversion stages that occur in present networks. By taking advantage of the multiplexing facilities offered by optical technology in the space, time and wavelength domains, it will be feasible to transport (transmit, switch and route) large streams of information in a reliable, flexible and economical manner. By applying this concept to the access network, it will be possible for subscribers to have access in a flexible manner to the communications network or networks via optical fibres over which they will transmit and receive the necessary information in accordance with the type of service to which the subscriber in question is seeking access at any given moment.

Different optical access network configurations, between the switching centres and the network terminating equipments, permit the signals to be transported correctly between the subscribers and the centre or centres to which they are connected.

Thus, for example, the European patent EP 0394728 presents one of these optical communications systems for the transmission of multiple services to a group of subscribers.

In this system, the subscribers are connected to a remote distribution unit by means of individual optical fibres, the connection between this distribution unit and the centre being made by means of a single optical fibre. In the direction from the centre to the subscribers, the individual lightwave signals are transmitted on a number of wavelengths equal to the number of subscribers (8 in the case described in the document mentioned,  $\lambda_1, \dots, \lambda_8$ ) and the common signals on another additional wavelength  $\lambda_0$  by means of wavelength division multiplexing.

These wavelengths are separated in the remote distribution unit, such that each of the eight wavelengths  $\lambda_1, \dots, \lambda_8$  plus the common wavelength  $\lambda_0$  are transmitted over the corresponding optical fibre that connects to each subscriber. Within the network terminating equipment detection is done, separately, of the signals associated with each of the received wavelengths.

In the other direction, from the subscriber to the exchange, the information originating at the subscriber end is transmitted over the same optical fibre but with different wavelengths ( $\lambda_9, \dots, \lambda_{15}$ ) to the remote distribution unit where they are combined by means of wavelength division multiplexing for the transmission of all the optical signals over a single optical fibre to the switching centre.

The fact that each network terminating equipment requires an optical transmitter and receiver working at different wavelengths than the other optical transmitters and receivers for the rest of the equipments, constitutes the main drawback due to high cost resulting from their low repetitivity factor, both in production and in installation and maintenance.

CHARACTERISATION OF THE INVENTION

The optical communications network according to the invention permits subscribers to have access to one or more types of service simultaneously, by being connected to the respective switching centres or, in general, service nodes, via an access node, the connections between this access node and the centre being made by means of optical fibre networks that employ wavelength division multiplexing techniques, and the connections between the access node and the network terminating equipments being made by means of optical fibre links in point-to-point or point-to-multipoint configurations made, in the latter case, by means of a passive optical network.

This communications network, which permits the provision of various types of service (narrow band and/or broadband, distribution, video on demand -VOD-, transparent connections, connection-free services, etc.) is particularly characterised in that the access to each type of service uses a wavelength that is common for all the network terminating equipments. In this way, each service type has a reserved wavelength which is that which will be received and/or transmitted by all network terminating equipments of subscribers to the type of service in question.

In the event that a user subscribes to several types of service and wishes to have access simultaneously to them, these will be transmitted over a single optical fibre at the wavelengths associated with each one, by means of wavelength division multiplexing.

The bidirectional links between a switching centre and the access node are made by means of a set of optical fibres on which are multiplexed together the signals corresponding to a number of subscriber lines that are active at that moment by wavelength division multiplexing techniques.

At the access node, the conversion is made of the wavelengths used in the span from the corresponding switching centre to the access node to that associated with the service in question, and the routing of these signals to the corresponding fibre for connection to the subscribers.

In similar fashion the signals in the opposite direction are transmitted from the network terminating equipments at the wavelength associated with this type of service and, at the access node, the conversion takes place from this fixed wavelength to another wavelength, which will be one available from a determined number. This optical signal is multiplexed with the other signals corresponding to other subscribers for transmission to the switching centre.

The above process is repeated at the access node for each type of service. The part of the access node through which access is made transparently to a determined service node is termed the Plane of Service.

With the arrangement described, it is possible, first, to have, on the subscriber side, for a given type of service, very simple and identical network terminating equipments since they all work at the same wavelength, consequently the cost of manufacture, installation and maintenance is much lower than if it were different terminals.

In addition, the provision of a new type of service can be done simply as it is only necessary to create a new plane of service in the access node, allocating to it a new wavelength, that corresponding to that type of service, and incorporate the appropriate optical transmitters and receivers in the network terminating equipments of those users that wish to subscribe to the new service. The incorporation of the new plane of service does not interfere with those already installed.

#### BRIEF FOOTNOTES TO THE FIGURES

Below a fuller explanation is given of the invention based on the description of an implementation of it according to the figures attached, in which:

- figure 1 shows an optical communications system, in accordance with the state of the art, for a cable television service and for a broadband integrated services digital network,
- figure 2 shows an optical communications network in accordance with the invention for access of net-

work terminating equipments to an optical type switching centre, and

figure 3 shows an optical-communications network like that above but which includes the connection of an ATM type optical switching centre to a transparent transport network (ether service) which at the other extremity is connected to another optical switching centre.

#### DESCRIPTION OF A PREFERRED IMPLEMENTATION

Major advances are foreseen in the development of broadband services in the coming years. These services must be carried on physical media which can provide the necessary transmission capacity, as well as ensuring the reliability and confidentiality of the transmitted information.

This challenge can be most easily met by the use of optical communication systems that extend to the subscriber premises, that is, the users subscribing to services based on this type of communications network will have, at least, one optical fibre that connects to the network terminating equipment which he has in his home or centre and in which the entire path, from the switching centre to the terminal, consists of optical fibres over which optical signals are transmitted. Consequently the conversion to electrical signals takes place only in the network terminating equipment to which the subscriber terminals are connected.

There are many optical communications network configurations for optical fibre subscriber access which can be more or less suitable, depending mainly on the technology available and on its cost at the time when this type of network, still essentially experimental, becomes practical on a large scale.

Figure 1 shows a communications system using optical fibre, based on the aforementioned principle and according to the state of technology, for the provision of two types of digital communications service: digital cable television and integrated services digital network facilities.

In this system, each subscriber  $S_1, \dots, S_g$  has an optical fibre  $L$  over which the optical signals involved are transmitted in both directions. It can be seen that, even although all the subscribers receive the same wavelength  $\lambda_0$  in the case of cable television, for the case of access to the integrated services digital network each subscriber must receive a different wavelength  $\lambda_1, \dots, \lambda_g$  from the others and transmit on another wavelength which also must not coincide with that transmitted by any of the others  $\lambda_0, \dots, \lambda_{1g}$ .

To this end, the subscriber terminating equipments, although similar to each other, are not identical since they differ, at least, in their working wavelengths.

Figure 2 shows the configuration of a preferred implementation of a communications network in accordance with the invention, for the provision of multiple broadband services.

This network is formed by a switching centre CE of an optical type (though it may also be of the electronic type), an access node AN that concentrates and/or multiplexes the optical signals of the network terminating equipments ONT in order to access the optical switching centre mentioned CE and the optical fibre networks that interconnect the optical network terminating equipments ONT, the access node AN and the switching centre CE.

This network also permits simultaneous access to the different communications services offered through the switching centre CE mentioned or through other switching centres (some of these could be the same as the one mentioned but belonging to another network operator) or other service nodes (not shown); for this operational division, as far as the type of service is concerned, it is known as the "plane of service". All the planes of service are incorporated into the transport network (network core) through the access node AN to which the network terminating equipments ONT have access via optical fibre.

Each subscriber has one or two optical fibres OF over which the information corresponding to each service is received and transmitted at the respective wavelength allocated to each of the services on a permanent basis.

In the network described herein a first wavelength  $\lambda_a$  is used for ATM services, a second wavelength  $\lambda_d$  for television distribution services and a third wavelength  $\lambda_o$  for an ether service (transparent optical channel, equivalent to a conventional leased line). In addition, there is another wavelength  $\lambda_c$  for connecting to the control network (not shown). All these signals are transmitted over optical fibres OF that connect the network terminating equipments ONT to the access node AN by wavelength division multiplexing.

All the optical network terminating equipments ONT or the part corresponding to each type of service are identical to each other and serve to multiplex and demultiplex the optical signals with different wavelengths  $\lambda_a$ ,  $\lambda_d$ ,  $\lambda_o$  corresponding to the different connections (services) requested by the subscriber so that, in this way, the different electro-optical transducers included in these terminals and corresponding to each service perform their function in complete independence from the others.

The access node AN also has a wavelength demultiplexer-multiplexer WDM for each subscriber, which demultiplexes the different wavelengths  $\lambda_a$ ,  $\lambda_d$ ,  $\lambda_o$  of each service originating in the subscriber premises and directs each of these to the corresponding plane of service in the access node AN; in the opposite direction, it multiplexes the different wavelengths  $\lambda_a$ ,  $\lambda_d$ ,  $\lambda_o$  coming from the corresponding planes of service in the access node AN and sends them to the subscriber premises.

It also includes main distribution frames MDF that allocate a connection to the subscribers at the access node AN in a dynamic or permanent form. These distribution frames are based on optical space switching techniques.

Finally, at the access node AN there is a set of  $k$  optical access boards OAB for each plane of service, which performs the following functions:

- in the upstream direction (from subscriber to switching centre), they first perform the conversion of the fixed wavelength coming from each subscriber equipment into another wavelength  $\lambda_i$  that is different for each active equipment, into a set of  $m$  different wavelengths and, second, the multiplexing of the  $m$  different wavelengths over one of the optical fibres that connect to the centre;
- in the downstream direction (from switching centre to subscriber), it performs the reverse process, that is, first the demultiplexing of the  $m$  different wavelengths received over one of the optical fibres coming from the switching centre CE and the conversion of these  $m$  wavelengths into the wavelength reserved for the service in question and which will be transmitted to the subscriber premises over the corresponding fibre.

The switching centre CE, which can be connected to more than one access node AN, receives the previously mentioned set of  $k$  optical fibres  $OF_1, \dots, OF_k$  over which are transmitted all the information for the  $m \cdot k$  active subscribers for a given service.

In like manner an access node can be linked to more than one switching centre. In the system of figure 2 the switching centre CE communicates with the optical network terminating equipments ONT only for the service for which the wavelength  $\lambda_a$  has been reserved (ATM service). Similarly the access node AN can be connected to other nodes that provide the same kind of service (but from a different operator), or another kind of service like, for example, television distribution or video on demand, or another type of special service.

In the case described, the switching centre CE is an optical centre which receives information coming from the access node AN via a set of optical fibres  $OF_1, \dots, OF_k$ , in which each of them transmits, by wavelength division multiplexing, the set of wavelengths  $\Sigma \lambda_i$  of the optical signals coming from a set  $m$  of optical network terminating equipments ONT. The functions of this centre are to demultiplex the wavelengths received and transmit them to a means of switching for routing to other networks or other terminals connected to this centre.

In the same manner as the optical network terminating equipments ONT are connected to the switching centre CE and/or to other centres or service nodes via the access node AN, it is also possible for other electro-optical equipments to do likewise; for example, terminals belonging to an existing network (FTL system in terminals, ATM MUX, etc.). In this way, the access node AN would also permit the access of these networks to the facilities or services provided by the networks that they access (virtual path and/or circuit switching and routing). In these cases, the corresponding signals that are wavelength multiplexed between the access node AN and the

switching centre CE would be the optical interface signals (2 Mbit/s, 155 Mbit/s, etc.) that are supplied by the equipments.

A switching centre, of the ATM type for example, could also have access, via an optical type access node AN, to the transparent connection services that can be provided by an ether network. Figure 3 shows this case in which, through the plane of service termed "ether", the links from a second switching centre CE, also of the ATM type, connect with the transparent connection transport network (for example, optical type distributors) for interconnection with other switching centres. The optical fibres have access to the plane of service at the allocated wavelength.

In a similar fashion to that employed for the case of optical network terminating equipments ONT, the conversion is done of the wavelengths corresponding to the signals on the centre trunks, from the allocated wavelength, for example  $\lambda_a$ , to a wavelength that is different for each signal  $\lambda_1, \dots, \lambda_n$ , which are multiplexed for transmission over a single optical fibre  $OF_e$  that is connected to the service network of the transparent transport network ET or "ether". The number of different wavelengths to be multiplexed is determined by the spacing between them which depends on the trunk transmission rate.

#### Claims

1. OPTICAL COMMUNICATIONS NETWORK for the connection of a set of network terminating equipments (ONT) and/or electro-optical equipments to a switching centre (CE), in which the flow of information between the two passes, in transparent form, through an access node (AN),

- in which the transmission of the signals between this access node (AN) and the switching centre (CE) is done on optical fibres by wavelength division multiplexing of a set of wavelengths,
- in which the transmission between the access node (AN) and the network terminating equipments (ONT) is done on optical fibre, characterised in that the information signals that are transmitted between the access node (AN) and the network terminating equipments (ONT) do so making use of a same wavelength reserved for each communications service.

2. OPTICAL COMMUNICATIONS NETWORK according to claim 1, characterised in that when there are multiple types of communications services, each one of them uses a different wavelength for access.

3. OPTICAL COMMUNICATIONS NETWORK according to claim 2, characterised in that in the direction of transmission from the switching centre (CE) to the subscribers to various communications services, the access node (AN) performs a conver-

sion of the  $m$  different wavelengths corresponding to  $m$  subscriber equipments, into the wavelength reserved for each service.

4. OPTICAL COMMUNICATIONS NETWORK according to claim 3, characterised in that the optical network terminating equipments (ONT) of the users subscribing to different types of communications services receive these services at the wavelengths reserved for each one of the services, over optical fibres by wavelength division multiplexing.

5. OPTICAL COMMUNICATIONS NETWORK according to claim 2, characterised in that in the direction of transmission from the subscribers to the switching centre (CE), the different wavelengths corresponding to each communications service coming from the network terminating equipments (ONT) are demultiplexed in the access node (AN) and each is applied to the plane of service corresponding to each type of service.

6. OPTICAL COMMUNICATIONS NETWORK according to claim 5, characterised in that at the access node (AN), and corresponding to each plane of service, a conversion is done from the wavelength corresponding to a determined service for each subscriber to a new wavelength within a set of  $m$  possible different wavelengths.

7. OPTICAL COMMUNICATIONS NETWORK according to claim 6, characterised in that the  $m$  wavelengths corresponding to  $m$  subscribers using a single service are multiplexed over an optical fibre that links the access node (AN) to the switching centre (CE).

8. OPTICAL COMMUNICATIONS NETWORK according to claim 1, characterised in that the connections by optical fibres between the access node (AN) and the network terminating equipments (ONT), are allocated on a permanent basis or in a dynamic manner, by means of space switching techniques.

9. OPTICAL COMMUNICATIONS NETWORK according to claim 1, characterised in that the access node (AN) also performs the interconnection between the switching centre (CE) of a given service and the service node of the centre of a transparent transport network (ET).

10. An access node (AN) for accessing an optical network from a plurality of optical network terminating equipments (ONT) of different subscribers, characterized in that all the optical network terminating equipments (ONT) transmit optical signals at the same wavelength, and that the access node (AN)

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comprises an optical access board (OAB) containing:

- a plurality of wavelength converters for converting each received optical signal to an optical signal with a subscriber-assigned wavelength, and
- a multiplexer for multiplexing the converted optical signals into one optical signal which is transmitted into the optical network.

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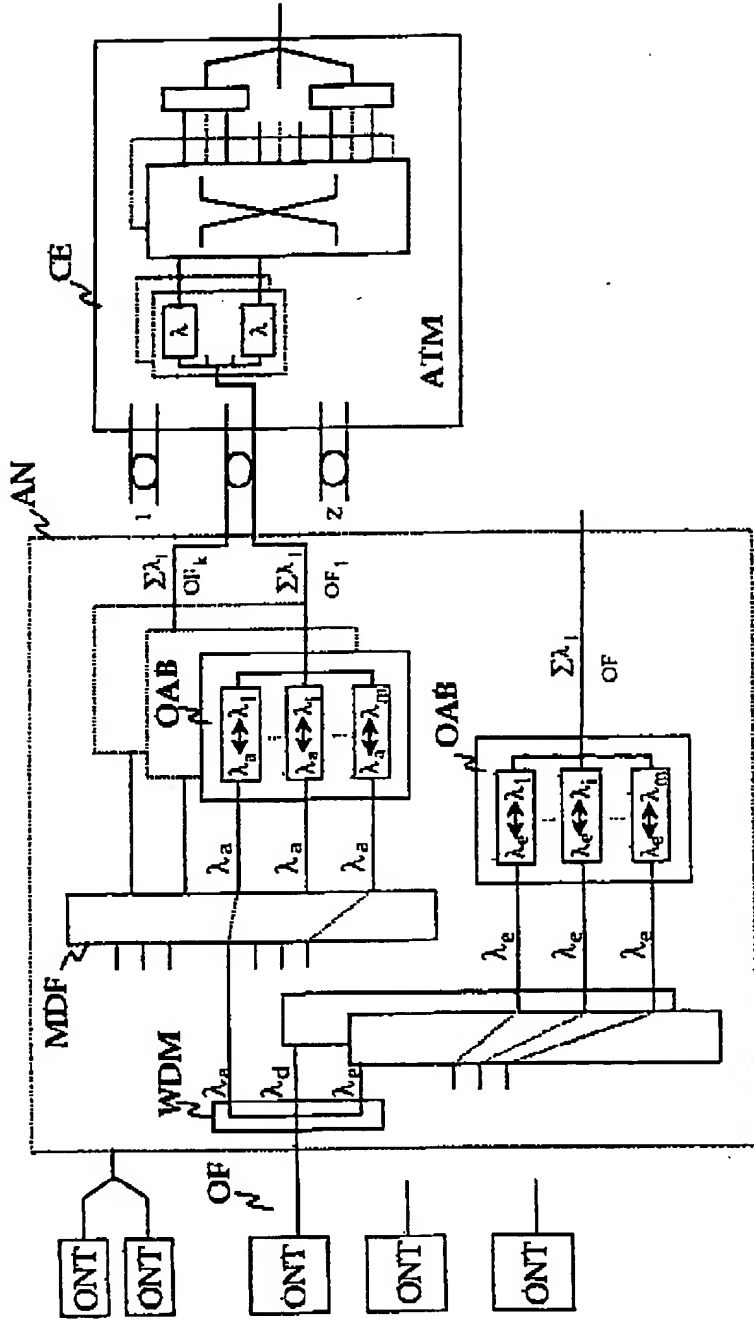


FIG. 2



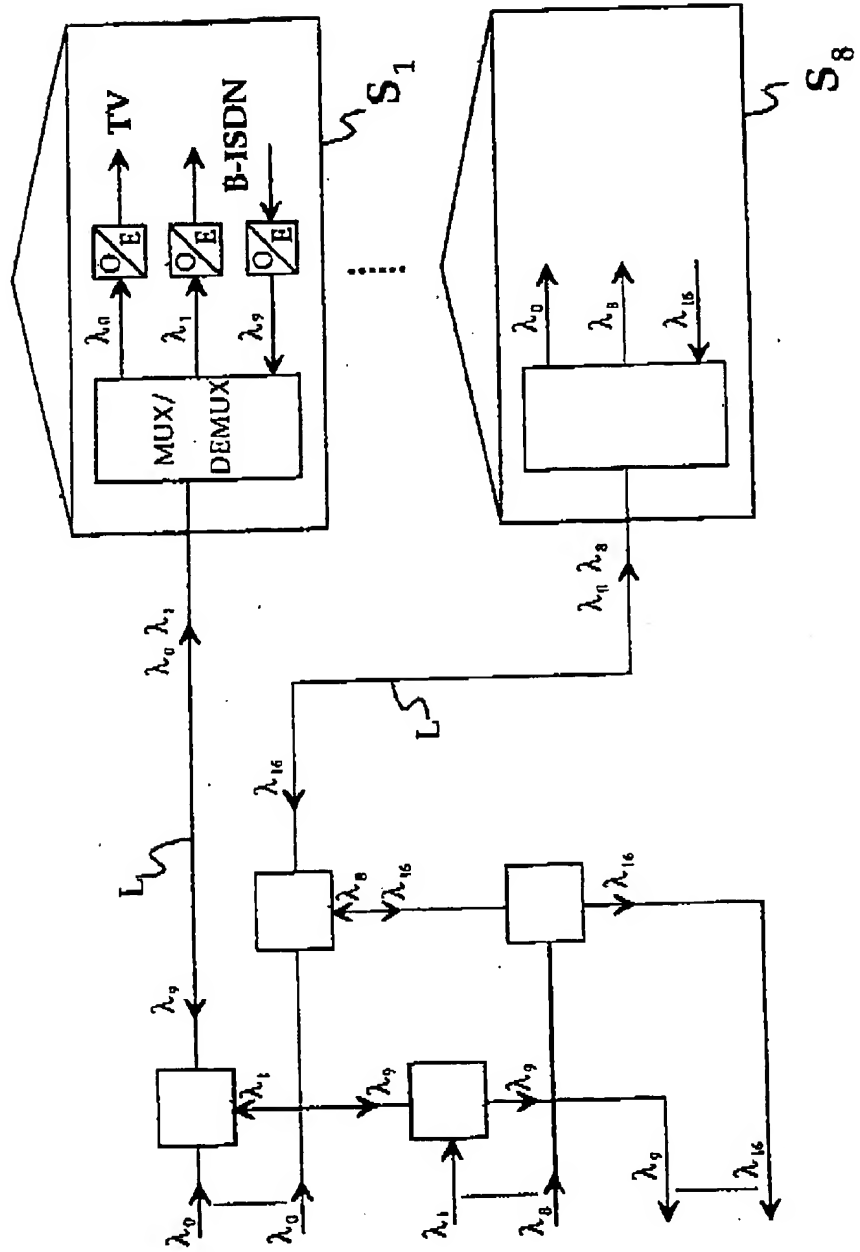
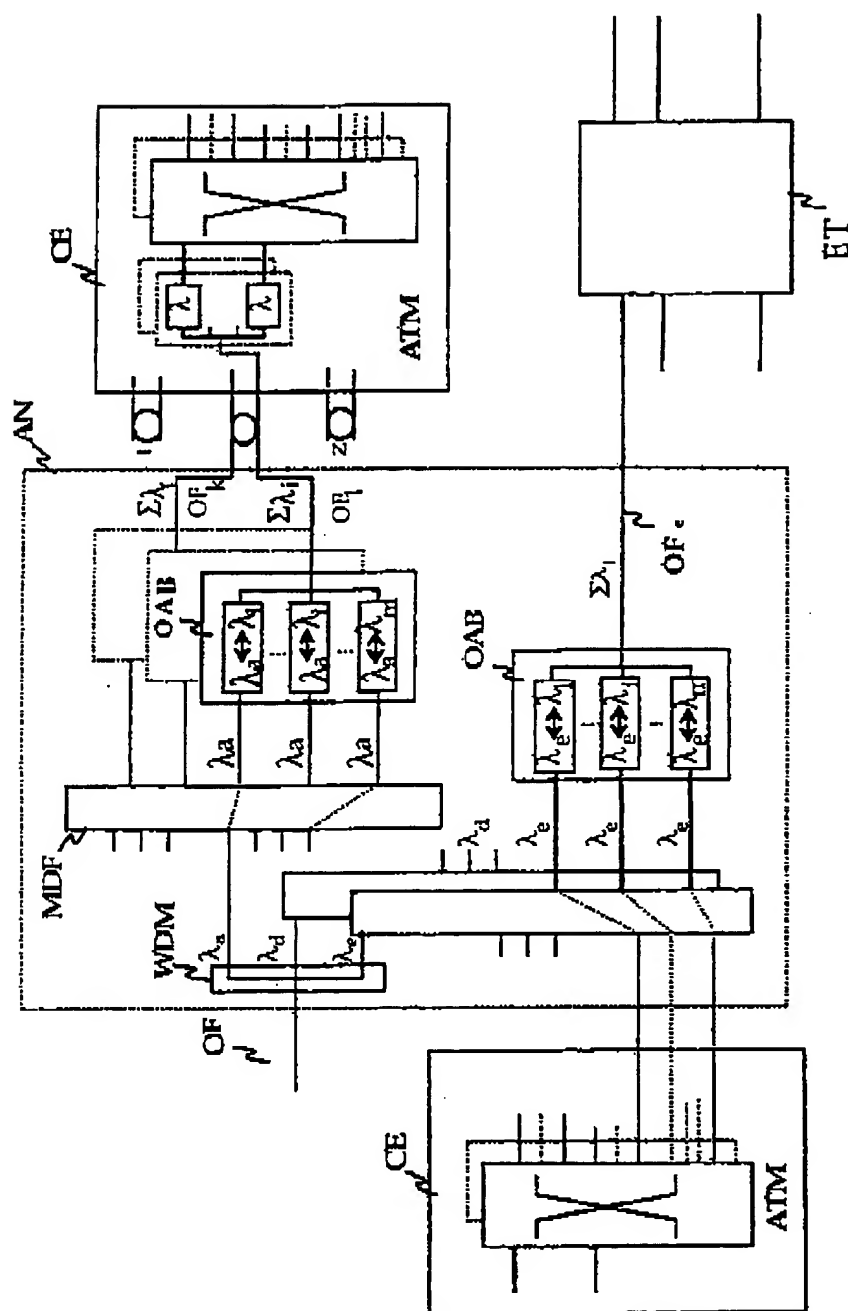


FIG. 1



**FIG. 3**

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(11)

EP 0 720 322 A3

(12)

## EUROPEAN PATENT APPLICATION

(88) Date of publication A3:  
10.06.1998 Bulletin 1998/24

(51) Int. Cl.<sup>5</sup>: H04J 14/02, H04N 7/22,  
H04B 10/207

(43) Date of publication A2:  
03.07.1996 Bulletin 1996/27

(21) Application number: 95120271.2

(22) Date of filing: 21.12.1995

(84) Designated Contracting States:  
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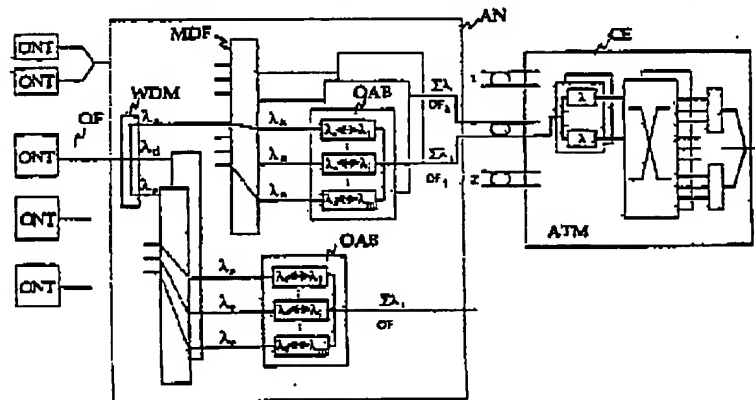


FIG. 2

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2.16.3/2.4

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EP 0 720 322 A3

European Patent  
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## EUROPEAN SEARCH REPORT

Application Number  
EP 95 12 0271

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Incl. 6)
X	SHIRO KIKUCHI ET AL: "OPTICAL WAVELENGTH-DIVISION MULTIPLEXING HIGH-SPEED SWITCHING SYSTEM FOR B-ISDN" COUNTDOWN TO THE NEW MILLENNIUM, PHOENIX, DEC. 2 - 5, 1991. vol. VOL. 2, no. -, 2 December 1991, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS. pages 1235-1239, XP000332855	1,2	H04J14/02 H04N7/22 H04B10/207
Y	* abstract *	3-7,10	
A	* page 1235, left-hand column, line 36-46 *		
	* page 1236, left-hand column, line 41-44; figures 3,5 *	9	
	* page 1236, right-hand column, line 30-39 *		
	* page 1236, right-hand column, line 47-52 *		
Y	EP 0 488 241 A (HITACHI LTD) * column 1, line 3-7 * * column 3, line 28-32 * * column 3, line 51 - column 4, line 49 *	3-7,10	TECHNICAL FIELDS SEARCHED (Incl. 6)  H04J H04B
A	EP 0 337 619 A (BRITISH TELECOMM) * page 2, line 1-3 * * page 2, line 36-43; figure 1 * * page 2, line 51-53 * * page 3, line 5-9 *	1,10	
D,A	EP 0 394 728 A (SEL ALCATEL AG ;ALCATEL NV (NL)) * column 1, line 1-3 * * column 8, line 47 - column 9, line 1; figures 1,3 *	1,8	
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>21 April 1998</b>	Examiner <b>Traverso, A</b>
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